The University of Chicago

STUDIES ON THE MOTILITY OF THE COLON

A DISSERTATION SUBMITTED TO THE FACULTY
OF THE DIVISION OF THE BIOLOGICAL SCIENCES
IN CANDIDACY FOR THE DEGREE OF DOCTOR
OF PHILOSOPHY

DEPARTMENT OF PHYSIOLOGY
1936

By
ELI LEROY BORKON

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A. The Influence of Enemas

Enemas or clysters were used as early as the fourteenth century B.C. (6). Pliny (13) ascribes the Egyptians' discovery of the enema from observations of the ibis. "In this same Egypt," says Pliny, "the bird called the ibis has taught us something similar. He washes the inside of his body by introducing water with his beak into the channel by which our health demands that the residue of our food should leave." The legend probably arose from the bird's habit of collecting oil from the preen-gland, situated close to the rump, with its long curved bill, which it keeps dipping into the water as it preens its feathers. Frequently, the evacuation of liquid feces must have been associated with the preening. Making a natural mistake, the Egyptians correlated the two unrelated acts. They knew nothing of the gland, nor did they suspect that the liquid feces were a mixture of feces and urine from the bird's cloaca. Louis XIV, in the seventeenth century, used many clysters to offset his imprudences of habit and diet (10).

After the Renaissance, enemas became extremely popular (10). Guy de Chauliac, the great surgeon, never went out without his clyster kit. With the waning of the eighteenth century, enemas became less a fad with the laity and more of a therapeutic measure. Among the physicians of the time, the chief interest centered about the amount, the components and the best method of administration of the enema (10).

In modern times enemas fill a definite need in clinical practice. Little exact work has been done to determine the

relative efficiency of enemas as evacuants or the effects of enemas on the gut activity. Hurst (6) stated, judging from observations of his house surgeon in 1912, that soap definitely increased the efficacy of enemas, probably by exerting a mildly stimulating action on the intestinal mucous membrane. Friedenwald and Feldman (2) studied the detrimental effects of prolonged use of various enemas. They found that tap water given once daily for 155 days caused a few hemorrhagic areas in the colon of two out of three animals. With soap, only one out of three showed this hemorrhagic appearance, while no change could be seen following cotton seed oil. Lewis (9) suggested that too large enemas may fail to elicit defecation, due to an overdistension of the gut and subsequent paralysis of the peristaltic waves.

In our work, we studied the relative efficiencies of one hundred and two hundred cc. quantities of soap suds, tap water, and white mineral oil enemas in eliciting defecation in dogs. We then determined the influence of these substances and of a fourth substance, bile, on the motor activity of the colon.

Fifty-seven control experiments and 390 enema experiments were performed on 4 cecostomized dogs. The dogs were trained to lie quietly on a soft pad, placed on a table, for the duration of an experiment. For recording the motility, a slight modification of the apparatus first described by Templeton and Bollens was employed (7). This consisted of two tandem balloon sets of three balloons each. One set, called the proximal set, was inserted through the cecostomy. The second set, called the distal set, was inserted by way of the anus. A small rubber tube was fastened between the middle and terminal balloons of the distal set. Through the free end of the tube, injections could be made into the colon without disturbing the dog or interfering with the

record of the colonic activity. The positions of the six balloons were checked roentgenologically. The balloon systems were connected to water manometers aligned to write on smoked paper, so that the activity in any segment of the colon at any moment could readily be observed.

The usual methods of showing the effects of drugs on gut motility have been to present a picture of the tracing most representative of the results obtained. We have departed from that method by transferring to graph paper a diagrammatic representation of the active and quiet periods. To do this, some arbitrary rules had to be made and strictly adhered to. The gut was said to be active if a contraction or contractions continued for one minute or more. The gut was said to be quiet if two minutes or more intervened between contractions. By this method, the active and quiet periods were pictured in sharp contrast. From the sum of the plotted activity, the percentage of time during which the gut was active could easily be computed for any desired duration of time. No attempt was made, in this study, to guage the amplitude of individual contractions.

In the controls, where no enemas were injected, and in the enema studies, two procedures were followed. The first procedure included experiments run 400 minutes without removing the balloons. These were called the continuous experiments. The second procedure included those experiments in which the balloons were removed after 200 minutes, the dogs allowed freedom outdoors, and after an interval of 30 minutes, the experiments resumed for another 200 minute period. Any enema injections were always introduced after 200 minutes of the experiment had been completed. This was the case in both the continuous and the interrupted type of observations. For purposes of comparison, the results were

grouped into four 50 minute periods in the first 200 minutes and a like number of 50 minute periods in the second 200 minutes of the tracing.

The first 100 minutes of each tracing was discarded, because of the influence of balloon insertions previously reported by Lawson and Templeton (8). It was found that the change in colon activity in the 50 minutes following immediately after various procedures as compared to the 50 minute control period immediately before these procedures best served to express our findings. The results in the entire 200 minutes after the various procedures (enema injections, defecation) maintained the same trends as were observed in the first 50 minute portion of this period.

In 97 observations on trained animals and 46 observations on animals used only once or twice after arriving in this laboratory, it was found that oil was only two-thirds as effective in eliciting defecation as soap and water enemas. To study the effect of retention of the enemas on defecation, the dogs were required to lie on their sides on tables for times ranging from zero to 120 minutes after the injection of the enemas. Upon allowing the animals freedom of movement and position after this retention, an inverse relationship was observed between the duration of the enema retention and the evacuation of the large bowel. Those animals retaining the enema longest defecated in the least number of instances (within the 30 minute time limit allowed). The untrained dogs gave a defecation response 10 to 30 per cent higher than the trained animals, irrespective of the time the enema was retained.

In the study of the effect of these substances on the colon motility, it was found in the continuous experiments that

oil increased the total quantity of activity more than soap or water. The work revealed (Tables I and II) that each animal had to be considered individually. However, the direction of influence of any of the enemas in relation to each other showed no difference on any of the animals.

TABLE I

PER CENT CHANGE OF ACTIVITY IN THE 50 MINUTES FOLLOWING THE TIME OF INJECTION OF 100 CC. ENEMAS, COMPARED TO THE 50 MINUTE PERIOD IMMEDIATELY PRECEDING

Enema*	Dog A	Dog B	Dog C	Dog D	All Dogs
None	+ 7	+ 6	- 0.3	+ 4	+ 4
Oil	+16	+20	+11	+14	+16
Water	- 7	-10	-25	...	-12
Soap	+ 0.4	-21	+ 5	...	+ 2

*Enema is retained after administration.

TABLE II

PER CENT CHANGE OF ACTIVITY IN THE 50 MINUTES FOLLOWING THE TIME OF INJECTION OF 200 CC. ENEMAS, COMPARED TO THE 50 MINUTE PERIOD IMMEDIATELY PRECEDING

Enema*	Dog A	Dog B	Dog C	Dog D	All Dogs
None	+ 7	+ 6	- 0.3	+ 4	+ 4
Oil	+17	+31	+27	+14	+21
Water	- 2	-12	+ 5	+ 6	+ 1
Soap	- 4	-28	+10	+ 1	- 4

*Enema is retained after administration.

In the interrupted experiments, only those were included in which the dog defecated upon removal from the table. Although the dogs in this study have been in the laboratory for two years or more and should therefore be accustomed to defecating in their runways, it was noted that they seldom defecated indoors in the thirty minutes of observation. It was necessary to take the dogs outdoors, where a defecation response often occurred even without an enema.

In general, in the interrupted experiments (Tables III and IV), it was evident that the most active colon following the enema and defecation was associated with oil. Nevertheless, this enema, as already pointed out, was the least effective in eliciting defecation. Dog D in Tables III and IV had no adequate controls, since he did not defecate in the allotted time, unless an enema was administered.

TABLE III

PER CENT CHANGE OF ACTIVITY IN THE 50 MINUTES FOLLOWING THE TIME OF INJECTION OF 100 CC. ENEMAS AND DEFECATION, COMPARED TO THE 50 MINUTE PERIOD IMMEDIATELY PRECEDING

Enema*	Dog A	Dog B	Dog C	Dog D	All Dogs
None	- 7	+11	- 2	...	+ 0.6
Oil	-12	+ 7	- 6	+17	- 5
Water	-20	-20	- 6	+17	-15
Soap	-18	-25	- 9	...	-12

*Enema is not retained — defecation occurs.

TABLE IV

PER CENT CHANGE OF ACTIVITY IN THE 50 MINUTES FOLLOWING THE TIME OF INJECTION OF 200 CC. ENEMAS AND DEFECATION, COMPARED TO THE 50 MINUTE PERIOD IMMEDIATELY PRECEDING

Enema*	Dog A	Dog B	Dog C	Dog D	All Dogs
None	- 7	+11	- 2	...	+ 0.6
Oil	- 6	+ 3	-12	+11	+ 0.2
Water	-30	-10	-12	+ 9	-13
Soap	-24	-23	-14	+18	-14

*Enema is not retained — defecation occurs.

The results indicated that the enema most likely to produce defecation did not do so by virtue of its ability to increase the gut motility, as is generally believed (10, 6).

Bile was selected as a fourth enema for study because of its reputed action on the intestine (15, 16, 3). Undiluted dog's gall bladder bile was injected in 10 and 20 cc. quantities into the gut lumen and compared to similar quantities of tap water. The same animals and methods were employed as with soap, water and oil enemas. Only the continuous type of experiments was performed.

Bile elicited a profound inhibition of colon motility, while water did not (Table V). Ott and Scott (12) obtained corresponding depression of activity with excised large intestine. Stadelmann (16) believed the opposite to be true.

Invariably, within ten minutes after being removed from the table, the dogs defecated following the use of bile. Such an observation was not a regular occurrence with any other enema studied. Since bile depressed colonic activity to such an extent

TABLE V

PER CENT CHANGE OF ACTIVITY IN THE 50 MINUTES FOLLOWING THE TIME OF ENEMA INJECTION COMPARED TO THE 50 MINUTE PERIOD IMMEDIATELY PRECEDING

Enema	Per Cent Change
None	+ 4
10 cc. bile	-24
10 cc. tap water	+ 5
20 cc. bile	-27
20 cc. tap water	- 3

and yet consistently caused defecation, the question of the mechanism of the inhibition and the mechanism of defecation must be raised. We saw previously that soap and water depressed gut activity as compared to oil, while being more efficient evacuants. Does the quiet colon then signify an urge to defecation? It is our opinion that during the time the animals were on the table, the conditions of the experiment and the unnatural posture for defecation were the inhibiting factors.

The prevailing explanation of the mechanism of defecation includes the motor activity of the large bowel, associated with increased intra-abdominal tension, propelling material within the bowel outward through relaxed sphincters (1, 14, 5, 6). We have no evidence to support this conception. Our evidence, from the enema study, suggests that increasing the intra-abdominal pressure may expel fecal material from the colon, even though the colon remains quiescent.

B. The Influence of Ileostomy

The influence of ileostomy on the large bowel motility was observed using the same technique as was employed in the enema study. The work was controlled by records taken of the motility of the colon in a cecostomized dog for three months prior to ileostomy. At the conclusion of the control period, the colon was separated from the upper part of the alimentary canal. The animal was allowed a short time for convalescence before resuming work. Fifteen days after the operation, observations were resumed, using the same method as before ileostomy. Heupke (4) reported that he was able to keep such an animal alive for 12 weeks, although most workers reported that ileostomy preparations died in 8 weeks. According to Ivy (7, 11), most ileostomy dogs die within 3 to 4 weeks after operation from dehydration. If they survive beyond this period, it is due to careful nursing. He said that the end of the ileum assumed the appearance of the colon in the surviving animals. There was dilatation and mucosal change. If death occurred in 4-6 months after operation, it was usually caused by an intestinal obstruction (7). Our animal has survived 4 years since operation. He was given repeated small feedings during the first three post-operative months, after which he was put on once a day feeding. His weight has increased 3 kilograms over the pre-operative level.

After ileostomy, we referred to the colon as being isolated (actually only divided from the rest of the gut). After isolation, the characteristic types of colon motility (8) were

not altered. It was evident at once, however, that the balloon inflation would have to be doubled over that used in the pre-ileostomy period if contractions of comparable height were to be obtained. Prior to isolation, it was often observed that the quiet periods of the colon following activity did not return to their previous pressure levels. In the ileostomy preparation, without exception, such variations in pressure levels were absent.

The normal cecostomized colon seldom gave a picture of regular periodic contractions. In the intervals between high Type III contractions, low Type II activity often occurred. After isolation, the low Type II contractions were conspicuously absent for a period of two months. Their absence strikingly revealed the essential periodicity of the colon activity. The absence of these low contractions might have been due to the operative procedure or to the discontinuity of the gut, which severed conducting elements. In addition, normal fecal material no longer accumulated. Two months after the ileostomy, the colon periodicity was again being obscured by the Type II contractions. However, even two years after the operation, occasional records of motility strikingly pointed out the periodicity. Evidently, then, the absence of low grade activity could not be the aftermath of the operative procedure. In those non-ileostomized animals where periodic motility was occasionally present, it was seen to occur following evacuation of the colon. The presence of the fecal material coming from the upper gut would then seem to be the factor ordinarily obscuring the underlying periodicity of the colon.

Summary

1. Comparison of the efficiency of soap, water and oil enemas in eliciting defecation in the dog placed soap and water as superior to oil.

2. Soap and water, if retained in the colon, augmented total colonic activity less than oil.

3. Soap and water, when followed by defecation, depressed the colonic activity more than oil.

4. Bile depressed colonic motility more than any other enema studied, yet invariably following its use defecation resulted.

5. It is suggested that defecation may occur in a relaxed or inactive colon solely by skeletal muscle contraction increasing intra-abdominal pressure.

6. Tne colon, after ileostomy, showed no change in characteristic types of motility.

7. After ileostomy, greater balloon inflations were necessary to obtain contractions of comparable height to those in the non-isolated colon.

8. After ileostomy, pressure level changes in the periods between colon motility were conspicuously absent.

9. Isolation of the colon accentuated the essential periodicity.

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